CHAPTER 10

CONCLUSION

10.1 INTRODUCTION

The thesis examines the process parameter optimization and characterization of Friction stir welding process of AA 5083. The responses that are considered for optimization are tensile strength of the FSW welded joint and the input power for the process. The significant process parameters were identified as well as the optimum levels of the process parameters were found out. The optimum levels of the parameter obtained by the three methods are given in Table 10.1.

Table 10.1 Optimum process parameters

<table>
<thead>
<tr>
<th>Sl .No</th>
<th>Method</th>
<th>Optimum Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Taguchi (Single objective)</td>
<td>Rotational speed - 650 rpm</td>
</tr>
<tr>
<td></td>
<td>Maximization of Tensile Strength</td>
<td>Transverse speed - 115mm/min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Axial load - 17 kN</td>
</tr>
<tr>
<td>2</td>
<td>Taguchi (Single objective)</td>
<td>Rotational speed - 500 rpm</td>
</tr>
<tr>
<td></td>
<td>Minimization of Input power</td>
<td>Transverse speed - 115mm/min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Axial load - 9 kN</td>
</tr>
<tr>
<td>3</td>
<td>Taguchi (Multi objective)</td>
<td>Rotational speed - 650 rpm</td>
</tr>
<tr>
<td></td>
<td>Weightage method</td>
<td>Transverse speed - 115mm/min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Axial load - 9 kN</td>
</tr>
<tr>
<td>4</td>
<td>Grey Relational Analysis</td>
<td>Rotational speed - 650 rpm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transverse speed - 115mm/min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Axial load - 9 kN</td>
</tr>
<tr>
<td>5</td>
<td>Full Factorial DoE</td>
<td>Rotational speed - 650 rpm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transverse speed - 135mm/min</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Axial load - 17 kN</td>
</tr>
</tbody>
</table>
The interaction effects are also studied. The microstructure of the FSW joints is obtained, which characterizes the increase of the tensile strength in the weldment.

To summarize the optimum parameters of FSW joint of AA 5083 for cylindrical tapered tool pin profile.

- The rotational speed of the tool plays a major role in the tensile strength of FSW joint. Irrespective of the methods used the optimum parameter for rotational speed of the tool is 650 rpm with respect to single and multiple objective optimization.

- The input power is directly proportional to the rotational speed of the tool.

- The optimum parameter for transverse speed is 115 mm/min. The tensile strength of the FSW joint decreases with increases in transverse speed.

- The power input increases significantly with increase in axial load.

- The optimum parameter for axial load is 17 kN.

- The rotational speed, transverse speed and axial load and their interactions significantly affect the tensile strength of the FSW joint.

- The optimum process parameter evolved in this investigation is $RS_2TS_1AL_3$ with tensile strength as objective function.
• The confirmation experiment run was conducted by setting the optimum parameter as $RS_2TS_1AL_3$. The tensile strength of the FSW joint at optimum condition is 301 Mpa. At optimum setting condition, no defects were seen.

• The optimum process parameter evolved with respect to maximization of tensile strength and minimization of the power input is $RS_2TS_1AL_1$.

• The confirmation experimental run was conducted by setting the optimum parameter as $RS_2TS_1AL_1$. The tensile strength of the FSW joint is 270 Mpa and 740 Watts.

10.2 CONTRIBUTION OF THIS RESEARCH

The contribution of this research is as follows:

• The process parameters of Friction Stir welding on AA 5083 are systematically optimized using Taguchi method, Design of experiments and Grey Relational Analysis.

• The optimum process parameters of FSW were found out to weld defect free FSW joints of AA 5083 using tapered cylindrical tool, supported by mechanical characterization, which is very much useful in naval application and welding cryogenic tanks.

• The effects of rotational speed, transverse speed and axial load on tensile strength of FSW on AA 5083 are studied.
The interaction effects of the FSW process parameters are revealed to be significant on the tensile strength of the welded joint.

10.3 IMPLICATION OF THIS RESEARCH

The implication of this research is as follows:

- The optimized FSW process parameter is very much useful in producing defect free joints in ship building and marine applications.

- As 100 % joint efficiency is obtained in the FSW welds, it contributes 30 % reduction in weight in ship building and marine application. The advantages of weight reduction in marine vessels increases the payload and decreased power consumption.

- The optimized process parameters hold an entry in the manufacturing data book of Naval Research Board.

10.4 SCOPE FOR FURTHER RESEARCH

Further research can be carried out as follows:

- The tool geometry plays a vital role in the material flow of FSW, which significantly affects the mechanical properties of weldment. The shape of the tool geometry can be varied and the same investigation be carried out further.

- Apart from these Taguchi and Grey Relational Analysis, Desirability Method, Genetic Algorithms, Principal
Component Analysis, Neural Networks, Fuzzy Logic and Evolutionary Optimizations Techniques can be used to select the optimal parameters to yield better results.

- An empirical relationship between the process parameter to the response can be evolved by conducting experiments in a wider range of process parameters.
- The same investigations can be applied for different materials.

10.5 LIMITATION OF THE RESEARCH

The limitation of this research is as follows:

- The optimized process parameter is applicable only for tapered cylindrical tool.
- The inclination of the tool is not possible by this indigenous designed machine.
- As the tool is stationary and the table of the machine is moving, the butt joints can be welded.